Permeability changes of simulated low permeable fault rocks induced by intermediate velocity friction test

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Earthquake events often associate with fluctuations of flow rate, pore pressure and pore fluid chemistry at a subsurface of earthquake rupture zones. The co-seismic hydrological changes are explained by changes in fluid permeability of fault zones during earthquakes, and the permeability change plays an important role for dynamic fault processes as well. Therefore, we newly designed a system to estimate water permeability changes during and after low to high velocity shear deformation using a rotary shear apparatus and simulated fault rocks.

A pair of hollow cylindrical samples made by low permeable Belfast dolerite and Aji granite were used as test specimens. To calculate permeability, a radial flow from the inner wall to the outer wall of the specimen was induced by applying a differential pore pressure (0.01 to 0.2 MPa) between inner and outer walls. We performed friction tests at normal stress of 2 MPa, rotation speed from 0.0003 to 0.6 m/s, and slip displacement of 1 m.

The results showed that permeability increased during sliding at every slip velocity condition, and higher velocity friction caused more abrupt increase in permeability. After the end of sliding, permeability gradually decreased with time and then became nearly constant value. Reduction rate of permeability 5 min after slip increased with slip rate. Fiction coefficient was decreased with sliding velocity. Frictional heating is a key to explain slip velocity dependence of permeability (flow rate). Temperature rise caused by frictional heating will reduce fluid viscosity, therefore, apparent permeability reduction after sliding can be explained by an increase in fluid viscosity by cooling. Pore pressure build-up by frictional heating can increase aperture, therefore, this process can explain permeability enhancement during sliding and velocity dependences on permeability increase and friction coefficient.

Keywords: permeability, friction coefficient, frictional heating

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